3.4 A NEW TALL-TOWER METEOROLOGICAL MONITORING SYSTEM

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1. INTRODUCTION

The Atmospheric Technologies Group of the Savannah River Technology Center operates an extensive meteorological monitoring network (Figure 1) of 13 towers in and near the Savannah River Site near Aiken, South Carolina (Parker and Addis, 1993). The data from this system are available in "real-time" for emergency response atmospheric release modeling and operational weather forecasting. Archived meteorological data from this network are used extensively for many programs including air quality modeling, facility safety analyses, extreme weather event studies, environmental remediation projects, and a multitude of various other engineering studies. In past years, ATG also had operated meteorological instrumentation at several levels up to 304 m on a nearby television transmission tower, however, this system was retired in 1998 at the request of the tower owner. In the 2002-2003 timeframe, a new television tower is being built at an adjacent site, and ATG will install a state-of-the-art meteorological monitoring system at the new tower to continue to meet programmatic objectives of the meteorological monitoring network.

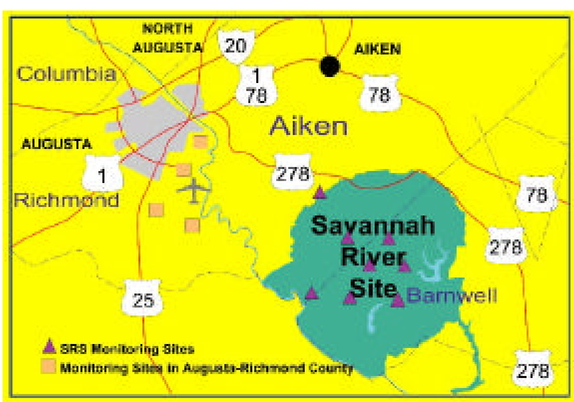

Figure 1. The meteorological tower network of the Atmospheric Technologies Group.

2. OBJECTIVES

The primary objective of the new tall-tower meteorological monitoring system is to enhance ATG's operational emergency response capabilities for unplanned atmospheric releases for both on- and off-site locations. However, the data from this system will also be available for atmospheric boundary layer (ABL) related studies. The measurements will be used to determine several terms of the classical turbulence kinetic energy (TKE) equation. Namely, these will include the buoyant production, shear production, and turbulent transport terms. Additionally, various forms of the Richardson Number and Monin-Obukhov Length will be determined. TKE can be used to approximate turbulent diffusion in the ABL, which is critical to ATG's mission.

3. INSTRUMENTATION AND CONFIGURATION

The new system will include sonic anemometers, fast-response water vapor, carbon dioxide (CO_2), and barometric pressure sensors, and slow response temperature and relative humidity sensors. Monitoring levels will be at 30 m, 61 m, and 304 m with future levels planned for 15 m and 137 m. A non-orthogonal three-dimensional sonic anemometer (Figure 2) will be used at the 61m and 304 m levels, and an orthogonal three-dimensional sonic anemometer (Figure 2) will be used at the 30 m level.

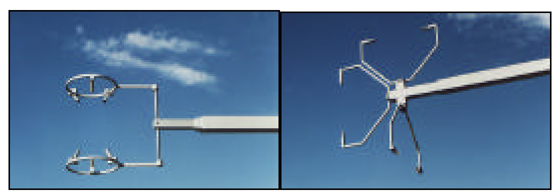

Figure 2. The non-orthogonal (left) and orthogonal (right) three-dimensional sonic anemometers.

The fast-response water vapor and CO_2 measurements will be made with an open path analyzer (Model 7500) (Figure 3) manufactured by Li-Cor, Incorporated of Lincoln, Nebraska. Changes in the absorption of infrared energy between the sensor head and base caused by ambient water vapor and CO_2 are converted to concentrations.

Figure 3. The fast response water vapor and CO_2 system.

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The pressure sensor is a board-mounted piezoresistive device manufactured by Silicon Microstructures, Incorporated of Milpitas, California. The slow response temperature (thermocouple) and relative humidity sensors (capacitance) are manufactured by Met One Instruments, Incorporated of Grants Pass, Oregon.

A typical boom and instrumentation configuration is shown in Figure 4. The protective boom is designed to deflect falling ice or objects from the upper portions of the tower. ATG's experience has shown that thick accumulations from ice storms will break off the tower in large pieces when temperatures moderate or, especially, when incoming solar radiation melts the ice that is in contact with the tower structure before the outer portions melt. Damages from falling ice can be substantial.

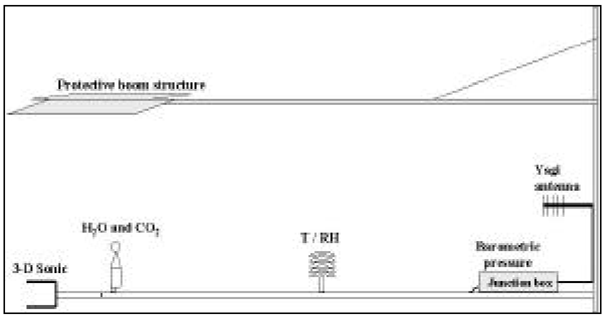

Figure 4. Schematic of a typical instrument and protective boom configuration.

4. DATA ACQUISITION

Data will be sampled and synchronized at the boom for each monitoring level. Data signals will be transmitted from each boom via Yagi antenna and spread-spectrum modem to a receiving antenna and modem located at ATG's facilities. The modems will be connected to a data-logging computer where data will be averaged and stored temporarily before transmission to ATG's permanent database. In addition, all raw data will be stored in a permanent database for reanalysis.

5. MEASURED AND COMPUTED VARIABLES

Mean values, covariances, and fluxes (Tables I and II) will be calculated for standard 15 minute averaging periods, and all raw data (10 Hz) will be

Table I. Variables

Symbol	Description	Units
U	True, three dimensional wind speed	m/s
V	Wind speed component perpendicular to U in the horizontal	m/s
W	Vertical wind speed	m/s
T	Virtual temperature from the sonic anemometer	°C
D	CO_2	g/m^3
Q	H_2O	g/m^3
P	Barometric pressure	hPa
t	Air temperature	°C
H	Relative humidity	%
S	Horizontal wind speed	m/s
θ	Horizontal wind direction	Deg
ϕ	Vertical wind direction	Deg
U	Vector averaged wind speed	m/s
σ_θ	Standard deviation of horizontal wind direction	Deg

available for reanalysis. These quantities will be measured or calculated for each monitoring level.

Table II. Additional Calculated Quantities

Name	Units
Mixing ratio	g/kg $_{air}$
Vapor pressure	hPa
Density of air	g/m^3
Specific heat of air at constant pressure	W-s/g-K
Heat of vaporization	W-s/g
Friction velocity (u_*)	m/s
Sensible heat flux	W/m^2
Latent heat flux	W/m^2
Sensible heat transport	W/m^2
Latent heat transport	W/m^2
CO_2 flux	g/m^2
CO_2 transport	g/m^2
Sonic roll	Degrees
Sonic pitch	Degrees
Boom angle	Degrees

Variances and covariances (Table III) will be calculated using the eddy correlation method.

Table III. Variances and Covariances

UU	TU	SU	DU	QU	PU	tU	HU
VU	TV	SV	DV	QV	PV	tV	HV
VV	TW	SW	DW	QW	PW	tW	HW
WU	TT	ST	DT	QT	PT	tT	HT
WV		SS	DS	QS	PS	tS	HS
WW			DD	QD	PD	tD	HD
				QQ	PQ	tQ	HQ
					PP	tP	HP
						Tt	Ht
							HH

6. A REGIONAL RESOURCE

It is anticipated that ATG's tall-tower meteorological monitoring system will provide data that is of interest to the regional meteorological community. For example, the data could be used for mesoscale modeling, long-term visibility and air quality studies, and fog forecasting to name a few. Inquiries pertaining to the data should be forwarded to the author.

7. REFERENCES

Parker, M. J. and R. P. Addis, 1993: Meteorological monitoring program at the Savannah River Site. WSRC-TR-93-0106. Westinghouse Savannah River Company, Aiken, SC 29808. pp. 87.